A study of forward-backward multiplicity correlations for UrQMD simulated Au-Au collisions at E_{lab} = 10, 20, 30 and 40A GeV

Danish F. Meer[1*] and M. Mohisin Khan[1]
[1]*Department of Applied Physics, ZHCET, Aligarh Muslim University, Aligarh, U.P.-202002, INDIA.*

INTRODUCTION

Correlations among final-state particles at various pseudorapidity (η) values produced in heavy-ion collisions is a vital probe to study the particle production mechanism. The forward-backward (FB) multiplicity correlations are of great interest as these are believed to reveal information regarding the earlier stages of the collision and are almost free from final-state effects [1]. According to the color glass condensate (CGC) model, the correlations originated in earlier stages of collision spread over long ranges of rapidity. Thus, studying the long-range correlations can be helpful to unravel the underlying dynamics of particle production in early stages of collision[1, 2].

The FB correlations can be of various types: multiplicity ($N_b - N_f$), mean or summed transverse-momentum ($P_T^B - P_T^F$) and multiplicty-momentum ($N_b - P_T^F$). Here we have only focused on the first type.

The forward-backward (FB) correlations are usually categorised into short-range correlations (SRC) and long-range correlations (LRC). SRC and LRC extend over small (upto one unit) and large η-ranges respectively.

FORMALISM

The strength of FB multiplicity correlation (b_{corr}) is characterized by Pearson correlation coefficient, and is defined as [3]:

$$b_{corr} = \frac{< N_b N_f > - < N_b >< N_f >}{< N_f^2 > - < N_f >^2}. \quad (1)$$

where N_b and N_f are the number of charged particles in the backward and forward η-regions respectively; falling within the chosen kinematic cuts of gap between the η-windows (η_{gap}) and the variable width of η-interval ($\delta\eta$). Here $\delta\eta = 0.2$ and particles only within the transverse-momentum (p_T) range of $0.15 < p_T < 2.0$ are considered for all energies. In heavy-ion collisions, the volume cannot be controlled and it varies on event-by-event basis; as the impact parameter is not same for different nucleus-nucleus collisions resulting in different centralities. Thus, there is a need of quantities which can be employed to extract the properties independent of volume fluctuations and such quantities are known as strongly intensive quantities; and for FB mul-

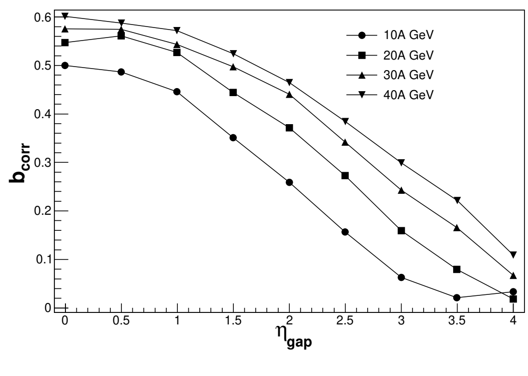

FIG. 1. Variation of b_{corr} as a function of η_{gap} for $0-10\%$ central Au-Au collisions at E_{lab} = 10, 20, 30 and 40A GeV.

* dfmeer.hep@gmail.com

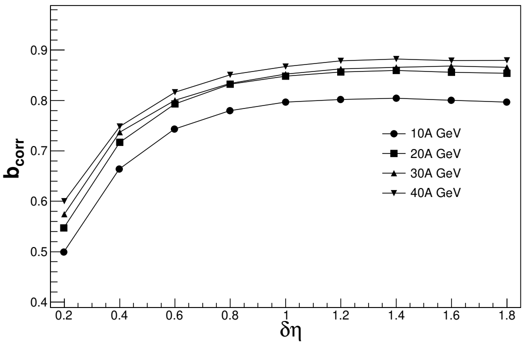

FIG. 2. Variation of b_{corr} as a function of $\delta\eta$ for $0-10\%$ central Au-Au collisions at $E_{lab}=10$, 20, 30 and 40A GeV. Here $\eta_{gap}=0$.

tiplicity correlation it can be written as [4]:

$$\Sigma = \frac{<N_b>\omega[N_f]+<N_f>\omega[N_b]-2D^2_{bf}}{<N_b>+<N_f>}, \quad (2)$$

where covariance is defined as:

$$D^2_{bf} \equiv <N_bN_f> - <N_b><N_f>, \quad (3)$$

and scaled variance is defined as:

$$\omega[N] \equiv \frac{D^2_N}{<N>} = \frac{<N^2>-<N>^2}{<N>}, \quad (4)$$

RESULTS AND DISCUSSION

The variation of b_{corr} with respect to the η_{gap} has been shown in Fig. (1) for $0-10\%$ central Au-Au collisions. The value of b_{corr} increases as we move from 10-40A GeV i.e., it increases with increasing energy. Also, the value of b_{corr} decreases with the increasing η_{gap}. The b_{corr} shows a saturation upto a value of $\eta_{gap}\approx 1.0$; and then afterwards there is a steep decrease and the steep is more pronounced as we move from higher to lower energies. The value of $b_{corr}=0.5$ means that the 50% of observed final-state particles are correlated.

The variation of b_{corr} as a function of $\delta\eta$ has been shown in Fig. (2) for $0-10\%$ central Au-Au collisions. Here the gap between the two windows i.e., $\eta_{gap}=0$. b_{corr} shows an increase upto the value of $\delta\eta\approx 1.0$; and then afterwards there is a saturation. The increase of b_{corr} can also be seen here as we move from lower to higher energies.

The variation of Σ with respect to the η_{gap} has been shown in Fig. (3) for $0-10\%$ central Au-Au collisions. The $\Sigma=1$ for independent particle production, and $\Sigma=0$ in case of no event-by-event fluctuations. The Σ shows almost the same behaviour with respect to the η_{gap} at all energies; except at $E_{lab}=10$A GeV which is closer to 1. The value of Σ is nearly 1 at all values of η_{gap} for all the energies.

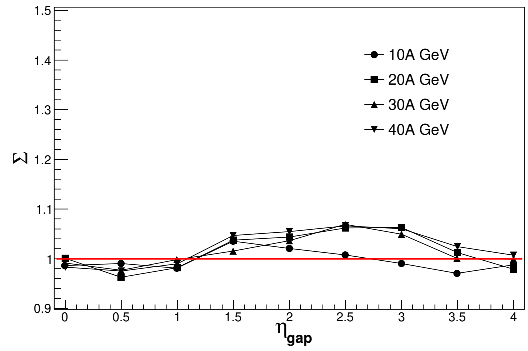

FIG. 3. Variation of Σ as a function of η_{gap} for $0-10\%$ central Au-Au collisions at $E_{lab}=10$, 20, 30 and 40A GeV.

[1] Kovchegov, Y. V., Levin, E., McLerran, L. Physical Review C **63(2)**, 024903 (2001).
[2] N. Armesto, L. McLerran, and C. Pajares, Nuclear Physics A **781**, 201 (2007).
[3] J. Adam, et al., Journal of High Energy Physics **05**, 97 (2015).
[4] M. Gorenstein and M Gaździcki, Physical Review C **84**, 014904 (2011).